academicJournals

Vol. 10(1) pp. 7-11, January 2016
DOI: 10.5897/AJFS2012.041
Article Number: 122706756937
ISSN 1996-0794

http://www.academicjournals.org/AJFS

African Journal of Food Science

Full Length Research Paper

Residual chlorine and pH influence on hygienic tap quality water consumed in Togo

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Received 9 March, 2012; Accepted 23 November, 2015

Water is used in personal hygiene, but also for food purposes. Unfortunately, the problem of drinking water consumption persists in developing countries. Water supply involves several stages from collection to storage through packaging and transport. During all these steps, the water can undergo various microbiological, physical and chemical contaminations that can transmit waterborne diseases among consumers. The characterization of the water quality is therefore important to protect the health of consumers. The main objective of this study was to assess the influence of residual chlorine and pH on microorganisms in drinking water. To this end, 30 water samples were collected in nine districts of Lomé in Togo. The spores were detected by routine standardized methods of the French Association for Standardization (AFNOR). The results of this study showed the presence of total spores with an average of 1.84 spore/ml in some samples despite the high levels of chlorine.

Key words: Tap water, hygienic quality, residual chlorine, Togo.

INTRODUCTION

Unsafe water kills more humans than all forms of violence. More than 3 million humans die annually from diseases related to water and the environment (WHO, 2005). If globally 2.4 billion people have access to safe drinking water and 600 million to sanitation over the last two decades, 1.1 billion still do not have access, while 3.5 million children die each year of waterborne diseases (Main causes of infant mortality on earth) (Marc, 2003). Water-related diseases are both due to lack of water, especially the lack of drinking water. Several writings including Nanga et al. (2014) and WHO (2005) highlighted the relationship between water quality and waterborne diseases. In Africa, poor quality water consumption is one of the leading causes of death (Bernadette, 2008; Anonymous, 2010). Compared to chemical processes, oxidation by agents such as chlorine and ozone, acts on metals (iron, manganese), on the organic matter and destroyed or inactivates totally or partially living spores, viruses and bacteria (CIEAU, 2008). Kahoul and Touhami (2014) reported that water supply must meet the quality requirements. Thus, it should not contain any microorganism, no noise and no substance presents a potential danger to human health; it must also comply vis-à-vis a set of standards for drinking water.

In Togo, like other sub-Saharan countries, the consumption of poor quality water is one of the causes of death. However the country has ratified various

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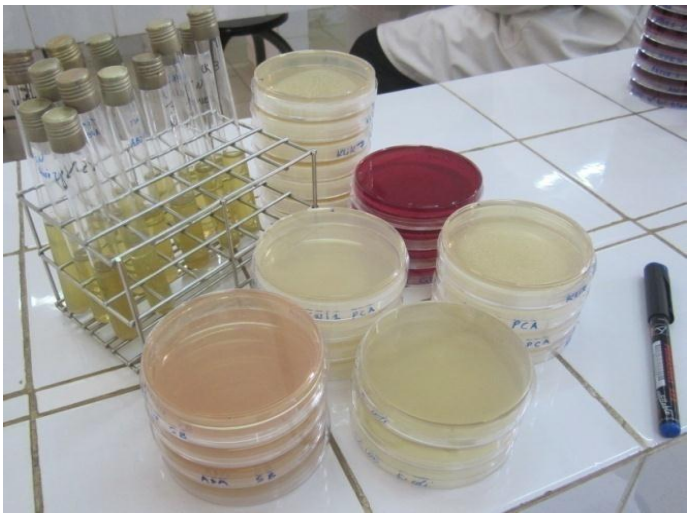

Figure 1. Petri dishes and tubes TSN.

Figure 2. Incubators (Jouan).

conventions and charters on water policy. Also, a lot of people as is the case in several countries in the world do not always have access to potable water. The vulnerability of aquifers to contamination and the high variability of hydrogeological situations require a specific study. Monitoring the hygienic quality of the water produced by the Togolese Water Company of the city of Lomé therefore remains a necessity to ensure safe drinking water to avoid water-borne diseases. The present work aims to analyze the tap water sampled in nine districts of the city of Lomé. For this, microorganisms have been searched, measured residual chlorine and pH in these water samples. The aim of this study is to verify the compliance of drinking water with respect to quality requirements adopted by the standards.

MATERIALS AND METHODS

Sampling took place from May 2 to July 4, 2011. Public tap water was taken at random in nine districts of the city of Lomé. This is the tap water produced by the Togolese Water Company (TdE). Samples collection and transport consist of bottles (Simax) 500 ml test tubes and a cooler (Igloo LEGEND 24, Igloo Products Corporation, USA) with cooling elements. The technical equipment consists of the spectrophotometer (Digitron Elvi 675, Logos Scientific, INC., USA), the pH meter (WTWpH 330i, Wissenschaftlich-Technische Werkstatten GmbH, WTW, Germany), brand Jouan incubators at 30, 37 and 44°C, binocular microscopes (Motic), an electric balance (Mettler P1210N, Mettler Toledo, Switzerland), an autoclave (Leuqueux, Paris). Some materials are illustrated by Figures 1 and 2.

The water samples were placed in a cooler (Igloo LEGEND 24, Igloo Products Corporation, USA) provided with cooling elements. It is advisable to keep the samples at a temperature of about 4°C to slow this bacterial activity (Aminot and Kerouel, 2004). The bacteriological parameters are considered the detection and enumeration of total bacteria, total coliforms, thermotolerant coliforms, *Escherichia coli*, fecal streptococci and sulphite-reducing anaerobic. The seeding technique in mass was used for detection and enumeration of spores. The total spores were detected with Plate Count Agar (PCA). With a sterile pipette, 1 ml of stock solution or one of its dilutions which are placed in petri box was taken. After pouring 20 ml of PCA, agar was incubated at 30°C for 24 to 72 h. Total coliforms were counted with crystal violet agar in neutral Red, the Bile and Lactose (VRBL). Incubation was at 30°C for 24 h. Enumeration of thermotolerant coliforms and *E. coli* is the same as total coliforms; however, the incubation was carried out at 44°C. Enumeration of *E. coli* is from boxes thermotolerant coliforms. Fecal streptococci were detected by the middle Slanetz and Bartley agar, incubated at 37°C for 24 to 48 h. The sulfite- reducing anaerobic bacteria (ASR) were detected by the Tryptone Sulfite Neomycin (TSN) agar tubes. 1 ml of the solution is introduced into 19 ml of TSN; the incubation was carried out at 44°C for 24 to 48 h. A subculture on nutritive agar has achieved the Gram stain. A colony was putted in the solution of hydrogen peroxide to search catalase. The colony was hit with a strip detection of oxidase to produce the oxidase test.

For the dosage of chlorine, residual was done with a spectrophotometer at the wavelength of 440 nm. 0.5 ml of 0.1% orthotolidine was introduced in a test tube and then 10 ml water sample was added. The pH was measured because the chlorine disinfection takes place best when the pH is between 5.5 and 7.5 (Florence, 2007). pH measurement is made using the pH-meter (WTWpH 330i, Wissenschaftlich-Technische Werkstatten GmbH, WTW, Germany).

Statistical analysis

GraphPad Prism 4.00 was used to analyze the results. The difference between the samples was determined by Tukey's test multiple comparison, by a safety factor of 95% and a degree of freedom at risk of 5%.

RESULTS

The results revealed the presence of aerobic mesophilic

Table 1. Assessment of the microbiological results.

Germs sought	Extreme values	General average (n = 30)	Criteria *	% of conformity
			m	Satisfactory
Total spores (30°C)	0 - 19	1.84	100	100
Total coliforms (30°C)	0	0	0	100
Thermotolerant coliforms (44°C)	0	0	0	100
Escherichia coli (44°C)	0	0	0	100
Fecal streptococci (37°C)	0	0	0	100
ASR (44°C)	0	0	2	100

*Criteria of the European Union Council Directive 98/83/EC (m); ASR: Anaerobic sulphite-reducing; n: number of samples analyzed.

Table 2. Distribution of organisms isolated by the catalase and oxidase tests.

Gram's coloration	Catalase	Oxidase	Number of spores	% (n = 30)
B+	+	+	5	17
B+	+	-	19	63
C+	+	-	3	10
C+	-	-	3	10

B^+ : Gram positive bacilli ; C^+ : Gram positive cocci ; +: positive; - : negative.

Table 3. Residual chlorine levels in the different districts.

S/N	Sampling point	Number of samples	Values > than reference (mg/L)	Quality limit/EU*(mg/L)
1	Abové	4	-	0.1
2	Atikoumé	3	0.7	0.1
3	Gbossimé	3	-	0.1
4	Doumassessé	4	0.2	0.1
5	Tokoin Lycée	3	-	0.1
6	Dogbéavou	3	0.2	0.1
7	Klikamé	3	-	0.1
8	Tokoin Trésor	4	-	0.1
9	Akodéssewa	3	-	0.1

*Criteria of the European Union (EU) Council Directive 98/83/EC.

total in 10 samples. On the other hand, other organisms have not been found sought. The results are shown in Table 1.

Total aerobic mesophiles were found whose values are between 1 and 19 microorganisms per ml of water. On the other hand, the absence of coliforms, *E. coli* as well as fecal streptococci and sulfite-reducing anaerobic were noticed.

Gram stain gave us 80% of spores found are Gram positive bacilli and 20% are Gram positive cocci. The catalase tests and oxidase showed that overall 90% of spores are catalase + and 10% are catalase -; 16.66% of spores isolated are oxidase + and 83.33% oxidase - with positive Gram bacilli, catalase + and oxidase +; positive Gram bacilli and catalase +, oxidase -; positive Gram cocci catalase + and oxydase - ; and positive Gram cocci, catalase - and oxidase - (Table 2).

For the 30 measured samples, three samples or 10% have a chlorine residual greater than the reference limit (Table 3).

The analysis of variance (ANOVA) and Tukey's test multiple comparisons showed that the difference of chlorine residual between samples is not significant. In three samples of different districts (Atikoumé, Doumassessé and Dogbéwavou) which have high levels of chlorine, we found the total spores in two of the sample types, Atikoumé (2 spores/ml) and Doumassessé (5 spores/ml). pH values in all 30 samples are within the limits selected by the criteria that is to say values between 6.5 and 9.5 according to Table 4. The

Table 4. Results of measurements of pH values in different districts.

S/N	Sampling point	Extreme values of pH	Quality limits/EU*
1	Abové	6.92 – 7.30	6.5 – 9.5
2	Atikoumé	6.93 – 7.03	6.5 – 9.5
3	Gbossimé	7.09 – 7.34	6.5 – 9.5
4	Doumassessé	7.03 – 7.60	6.5 – 9.5
5	Tokoin Lycée	7.05 – 7.11	6.5 – 9.5
6	Dogbéwavou	6.97 – 7.24	6.5 – 9.5
7	Klikamé	7.10 – 7.16	6.5 – 9.5
8	Tokoin Trésor	6.99 – 7.10	6.5 – 9.5
9	Akodéssawa	7.10 – 7.18	6.5 – 9.5

*Criteria of the European Union Council Directive 98/83/EC, 1998.

disinfection efficiency is determined by the pH of water. The highest value of pH is 7.60 found in a sample of Doumassesse. The lowest value of pH is observed at above with a pH equal to 6.92.

DISCUSSION

According to guidelines set by the European Union, the total bacteria found are below the limit considered. Our results are not similar to those obtained by Mokofio et al. (1991) in Bangui (Republic of Central Africa), that show the presence of faecal bacteria in samples of well water consumed. Degbey et al. (2009) also revealed the presence of bacteria of fecal origin in ten samples of well water consumed at Godomey, Abomey in Benin in 2009. In a study in Côte d'Ivoire in 2006, Odile et al. (2006) found an abnormal concentration of thermotolerant coliforms in the drinking water packaged collected from the market in Abidjan.

However, our results are consistent with Nola et al. (1998) in a study conducted in Yaoundé (Cameroon) on well water for drinking, which found only the total bacteria in their samples.

These results confirm studies of Jabu (2007) in Malawi on household water and Dianou et al. (2002) in Burkina Faso on the bacteriological quality of well water in rural areas, where a lack of fecal bacteria was observed. The presence of these spores proves the vulnerability of water to global pollution, inadequate treatment or an unsafe environment (Camille and Bernard, 2006; Degbey et al., 2010). The water supply must meet the quality requirements. Thus, it should not contain any microorganism, no noise and no substance presents a potential danger to human health; it must also comply vis-à-vis to a set of standards for drinking water (Kahoul and Touhami, 2014). The presence of residual chlorine prevents the breakdown of microbial quality and protects the water during distribution. The bactericidal action of chlorine increases for low values of pH of water, the high pH affects the action of chlorine (François, 2010).

pH values obtained in our study were between 6.5 and 9.5. Note that unlike tap water, in well water, studies (Degbey et al., 2010) showed pH below normal. The values of pH found in our study did not influence the dissolution in water of chlorine, hypochlorous acid and hypochlorite ions in toxic spores. Thus, the pH did not significantly affect the bactericidal action of chlorine. These results are justified in so far as the treated water is not sterile. Moreover, if lower residual chlorine may promote bacterial growth in the network, the study showed that maintaining residual chlorine did not provide completely preventing bacterial growth. The effectiveness of chlorine on microorganisms depends on the type of microorganism, and contact time. That justifies the presence of spores in the samples that have high levels of chlorine.

Conclusion

The study has shown that the bacteriological quality of the water is compliant for human consumption. However, we note the presence of the total mesophilic flora, which implies that tap water should be checked regularly for the well-being of consumers. This study on the hygienic quality of tap water is not exhaustive. It is important to consider other extensive studies in this area given the many parameters to consider in ensuring the quality of drinking water.

Conflict of Interests

The authors have not declared any conflict of interests.

ACKNOWLEDGEMENTS

The authors thank all the staff of Microbiology Laboratory and Quality Control of Foodstuffs and Water Chemistry Laboratory of the University of Lomé: Mr. Y. Adjrah, T.

Kokou Anani, Kangni-Dossou, and managers of standpipes and water kiosks.

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